Warm-up effect on handgrip strength in sedentary and overweight women

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Abstract: Introduction: The evaluation of handgrip strength has gain special relevance in the area of health. However, a standardized protocol of application is required to measure it, including warm-up procedures.Objective: To compare the acute effects of different warm-up strategies on maximal handgrip strength (MHS) in sedentary and overweight women.Materials and methods: Single-blind, randomized, cross-over study in which MHS was measured in 12 overweight women under the following conditions: i) no warm-up (control condition), ii) static stretching warm-up, iii) strength-based warm-up (i.e., resistance band exercise), and iv) isometric squeezing-ball warm-up for the forearm muscles. A Jamar dynamometer was used for the measurements, which were taken on four different days, at 48-hour rest intervals; three measurement were made per hand.Results: MHS mean values were 23.8 and 24.9 kg without warm-up, 20.3 and 21.4 kg after stretching warm-up, 20.9 and 22.9 kg after strength-based warm-up, and 22.0 and 23.0 kg after squeezing-ball warm-up for non-dominant and dominant hand, respectively. No significant (pgt;0.05; one-way ANOVA) differences were observed between protocols, nor differences in MHS in relation to nutritional status, lean mass or fat mass.Conclusion: Warm-up is not required to measure MHS in overweight sedentary women when three measurements are made.

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Abstract

Introduction: The evaluation of handgrip strength has gain special relevance in the area of health. However, a standardized protocol of application is required to measure it, including warm-up procedures.

Objective: To compare the acute effects of different warm-up strategies on maximal handgrip strength (MHS) in sedentary and overweight women.

Materials and methods: Single-blind, randomized, cross-over study in which MHS was measured in 12 overweight women under the following conditions: i) no warm-up (control condition), ii) static stretching warm-up, iii) strength-based warm-up (i.e., resistance band exercise), and iv) isometric squeezing-ball warm-up for the forearm muscles. A Jamar dynamometer was used for the measurements, which were taken on four different days, at 48-hour rest intervals; three measurement were made per hand.

Results: MHS mean values were 23.8 and 24.9 kg without warm-up, 20.3 and 21.4 kg after stretching warm-up, 20.9 and 22.9 kg after strength-based warm-up, and 22.0 and 23.0 kg after squeezing-ball warm-up for non-dominant and dominant hand, respectively. No significant ($p>0.05$; one-way ANOVA) differences were observed between protocols, nor differences in MHS in relation to nutritional status, lean mass or fat mass.

Conclusion: Warm-up is not required to measure MHS in overweight sedentary women when three measurements are made.

Keywords: Muscles; Body Fat; Women; Sarcopenia; Muscle Strength (MeSH).

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Resumen

Introducción. En los últimos años se ha dado una mayor importancia a la medición de la fuerza máxima de agarre de mano, sin embargo para hacer esta medición se requiere un protocolo estandarizado de aplicación, incluyendo procedimientos de calentamiento.

Objetivo. Comparar los efectos agudos de cuatro tipos de calentamiento en la fuerza máxima de agarre de mano de mujeres sedentarias con sobrepeso.

Materiales y métodos. Estudio ciego, aleatorizado y cruzado en el que se midió la fuerza máxima de agarre de mano de 12 mujeres con sobrepeso bajo las siguientes condiciones: i) sin calentamiento (condición de control), ii) con calentamiento de estiramiento estático, iii) con calentamiento basado en la fuerza (p. ej., ejercicios con banda elástica) y iv) con calentamiento con bola terapéutica de compresión para los músculos del antebrazo. Para las mediciones se utilizó un dinamómetro Jamar y estas se realizaron en cuatro días diferentes y en intervalos de 48 horas de descanso; además, se hicieron tres intentos de medición por mano.

Resultados. Los valores promedio de fuerza máxima de agarre para la mano no dominante y dominante fueron 23.8kg y 24.9kg sin calentamiento, 20.3kg y 21.4kg con estiramiento, 20.9kg y 22.9kg con banda elástica y 22.0kg y 23.0kg con bola terapéutica, respectivamente. No hubo diferencias significativas ($p>0.05$; ANOVA de una vía) entre los protocolos, ni diferencias en la fuerza máxima de agarre de mano en relación con estado nutricional, masa magra o masa grasa.

Conclusión. No se requiere una sesión de calentamiento para medir la fuerza máxima de agarre de mano en mujeres sedentarias con sobrepeso cuando se realizan tres intentos de medición.

Palabras clave: Músculos; Mujer; Sarcopenia; Fuerza muscular (DeCS).

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Introduction

Loss of muscle strength (dynapenia) (1) has a negative effect on morbidity and mortality (2). Therefore, the timely assessment of muscle strength is fundamental in preventive medicine (3).

The handgrip strength test is a validated and simple test used to assess muscle strength in several health-related contexts (4-10Despite its importance in clinical practice, there is a wide range of choices regarding the equipment and protocols to use when measuring maximal handgrip strength (MHS) (11). Particularly, the effects of warming-up before performing a MHS tests have not yet been described.

A warm-up is generally intended to generate an increase in muscle temperature facilitating increased blood flow, optimizing metabolic responses (12-13), reducing the muscle’s viscous resistance (i.e. smoother contraction) and increasing the speed of nerve transmission (14). By extension, the search for an optimal muscle temperature range that limits fatigue as much as possible whilst maximizing performance (12-15) seems prudent. Commonly, warm-up protocols tend to reflect the experience of individual researchers and practitioners, with most studies performed in athletes (16). Controlled studies regarding the effects of warm-up on maximal performance are particularly scarce, maybe due to the unwillingness of voluntary subjects to complete a maximal effort without warm-up (i.e. control condition). Among the studies investigating the effect of warm-up protocols on muscular performance (e.g., maximal strength), conflicting results have arisen, with some studies showing an increase in performance after specific (17) or combined general and specific warm-up (18), while others have not (16).

Considering the lack of studies addressing the effects of warm-up on sedentary females with overweight and MHS, and the clinically relevant applicability of MHS in community-health programs (19), a standardized protocol of application is required. The aim of this study was to compare the acute effects of different warm-up strategies on MHS in sedentary females. It was hypothesized that different warm-up protocols would induce an effect on MHS.

Methods

Ethical approval

This study (study protocol N° 103- 2018) was approved by the Institutional Review Board of the Department of Physical Activity Sciences, Universidad de Los Lagos, as it is stated Minutes DECAF2016/3, issued on April 25, 2016. The participants who agreed to participate signed an informed consent form, after receiving an explanation of the risks and benefit derived from their participation in the study. The study was conducted according to the ethical principles of the latest version of the Declaration of Helsinki 2013 (20).

Subjects and procedures

By publicity in a local University, sedentary and overweight females (n = 12, age, 21.1±2.0 y; 38.1%±8.4% fat mass; further descriptive characteristics in table 1) were recruited in a single blind, randomized and cross-over study design. Participants completed four different measurement protocols to assess MHS, with 48 h of rest between each.

Table 1. Baseline characteristics of the sample.

Variables	Mean	SD
Body mass (kg)	64.5	9.1
Height (m)	158.3	8.4
Body mass index (kg/m^{-2})	26.3	3.9
Body fat (kg)	24.8	7.3
Lean mass (kg)	22.1	3.3
Water (L)	29.8	4.0
Lean mass left hand (kg)	2.1	0.4
Lean mass right hand (kg)	2.1	0.4
Fat mass left hand (kg)	1.8	0.7
Fat mass left hand (kg)	1.8	0.7

Abbreviations: kg: kilograms; m: meter; kg/m^{-2}: kilograms by square meter; L: liters.

Source: Own elaboration based on the data obtained in the study.

To be included in the study, participants were required to: i) be over 18 years old, ii) be sedentary (weekly physical activity level = 600 METs.min.week) (21), iii) be free of cardiovascular, pulmonary or skeletal muscle pathologies (22), iv) have a fat mass >30% of total body mass. All experimental procedures were performed under controlled and standardized conditions in the Laboratory of Human Performance at the University where the study was conducted, always at the same time of day, temperature, humidity, rest time (i.e., sleep hours before testing), menstrual cycle phase, and hours post last meal. Subjects' height (Bodymeter 206, SECA, Germany to 0.1 cm), body mass and body composition (InBody120, tetrapolar 8-point tactile electrodes system, model BPM040S12F07, Biospace, Inc., USA, to 0.1 kg) were measured according to previous recommendations (23).

Measurement of handgrip strength

The test was applied according to previous recommendations (24). To assess MHS, an adjustable digital dynamometer was used (Jamar®, PLUS+, Sammons

Preston, Patterson Medical, Illinois, United States). After randomly assigning the order of dominant and non-dominant hand assessment, subjects had three valid attempts to achieve MVIHS for both dominant and non-dominant hands, with 2 minutes of rest between attempts. For each maximal attempt, subjects were asked to exert 5 seconds of maximal effort, while receiving standardized verbal motivation. Subjects completed each maximal attempt while seated on a chair in an erect position. The hip, knee, and elbow were flexed to a 90° angle and the shoulder was abducted and neutrally rotated. The forearm was in a neutral position and the wrist was slightly extended (0° to 30°). Subjects performed the test with a horizontal cylinder handgrip using the position II on the digital dynamometer, while the evaluator lightly supported this in its base. The best result (expressed in kg) of the three valid maximal attempts for each hand was chosen for statistical analysis.

Warm-up protocols

Four randomly selected warm-up protocols (Table 2) were applied for the forearm muscles of both the dominant and non-dominant hands as follow: i) no warm-up (control condition), during which subjects remained seated comfortably for three minutes before testing; ii) static stretching warm-up which subjects carried out static stretching of the forearms flexors and extensors muscles for a total of five sets of five seconds each (25); iii) strength (i.e. elastic band-based) warm-up during which subjects completed two sets of ten repetitions for the forearm flexor muscles for a duration of 2.5 seconds for each contraction (26) using an elastic band (THERA Band™; medium intensity, blue color) and 30 seconds to one minute of recovery between sets; and iv) isometric therapeutic squeezing-ball warm-up during which subjects completed one grip per 2.5 seconds (for a total of twenty repetitions) on a therapeutic squeeze ball (27). The ten point Borg scale of subjective perception of effort was used to measure the intensity during warm-ups to standardize intensity across all conditions, always between 3 and 6 points. After the warm-ups, three minutes elapsed before MHS testing.

Table 2. Characteristics of the warm up protocols.

Warm up	Exercises	Sets	Repetitions	Recovery between sets	Recovery after warm up
No warm-up	-	-	-	-	-
Static stretching	Static flexion of wrist Static extension of wrist	**5** **5**	5 seconds 5 seconds	30 seconds 30 seconds	3 minutes
Elastic band	Dynamic flexion of wrist	**2**	10	30 seconds	3 minutes
Isometric therapeutic squeezing-ball	Squeeze and release	**1**	20	30 seconds	3 minutes

Note: the table is an elaboration of the authors, based on the data of the present study.

Statistical analysis

All values are reported as means ± standard deviations. The Shapiro-Wilk and Levene's tests yielded non-significant values for all data. To determine the effects of the conditions on MHS absolute mean differences between conditions were compared using a repeated measures analysis of variance, with Fisher post hoc procedures. The α level was set at $p < 0.05$ for statistical significance, with Cohen's *d* representing effect size (ES) interpreted as <0.2 = trivial; 0.2-0.6 = small; >0.6-1.2 = moderate; >1.2-2.0 = large; >2.0-4.0 = very large; >4.0 =

extremely large). The reliability of the assessments was determined using the intra-class correlation coefficient. All measurements yield values ≥0.9.

Results

The MHS mean values for the non-dominant and dominant hand were, 23.8 kg and 24.9 kg after no warm-up, 20.3 kg and 21.4 kg after the stretching warm-up, 20.9 kg and 22.9 kg after the strength warm-up, and 22.0 kg and 23.0 kg after the squeezing-ball warm-up, respectively (Figure 1). No significant differences ($p>0.05$; $ES<0.2$) were observed among warm-up protocols.

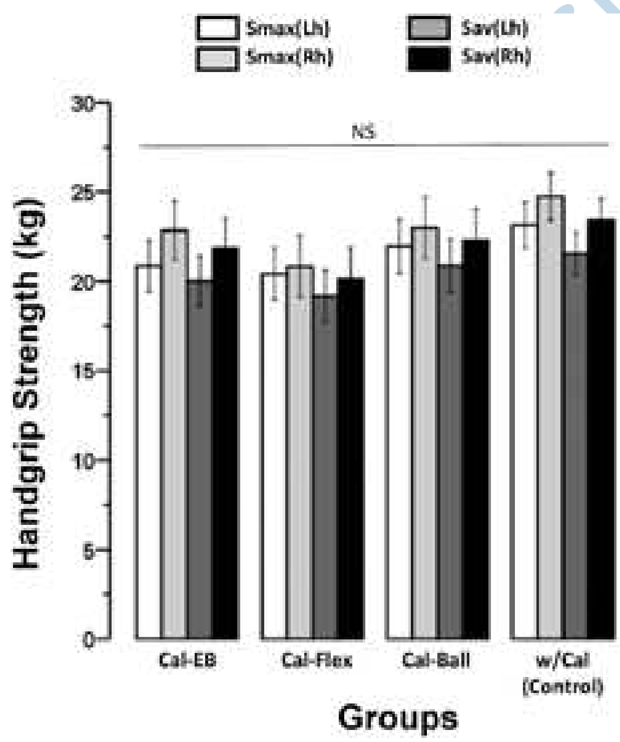

Figure 1. Abbreviations: Lh: left hand; Rh: right hand; Sav: Denotes mean maximal strength values from three measurement attempts; Smax: Denotes maximal strength value from three measurement attempts; Cal-EB: strength warm-up; Cal-Flex: stretching warm-up; Cal-Ball: squeezing-ball warm-up; w/Cal: no warm-up; kg: kilograms. NS: Denotes non-significant differences within-groups and between groups. Note: the figure is an elaboration of the authors, based on the data of the present study.

For the maximal strength value obtained from three MHS attempts (Smax in figure 1) and the mean strength value obtained from three MHS attempts (Sav in figure 1), no significant differences were observed between values ($p>0.05$; $ES<0.2$).

Discussion

The aim of this study was to compare the effects of different warm-up protocols on MHS. Main findings suggest that the three randomly selected warm-up protocols had no effect on MHS in a sample of 12 sedentary and overweight females. Moreover, a reduced MHS trend was observed in the participants after performing a static stretching based warm-up.

Regarding static stretching in warm-up routines, Behm et al. (28), in a study about the effects of static stretching warm-up on the strength of quadriceps muscles, reported a significant 12% maximal isometric strength decrease. Similar results have also been described for the pectoralis major and the triceps brachii muscles (29). In this sense, the results reported in the current study are in agreement with the aforementioned findings (28-29), since forearm flexor and extensor muscles static stretching, regardless of hand dominance, negatively affected MHS in sedentary and overweight females. Several factors may help to explain the impairment in MHS after static stretching, such as alterations in the mechanical components of muscle contraction (30), decreased muscle activation (28), or both (30).

In the current study, compared to the control condition, there were no improvements in MHS after the warm up with elastic band. This finding is in contrast with the results of a study conducted by Tilley and Macfarlane (31), where an increase in swing performance was demonstrated in elite male golfers after a warm-up with a rubber band. In male judokas, a warm-up with an elastic band allow them to improve the high jerk test performance when compared to a control condition (32). Moreover, Mina et al. (33), observed an increase in maximal squat strength in men after a warm up with an elastic band. In addition, in a study conducted by Aandahl et al. (34) an increase in the maximal kick speed in martial arts fighters was observed leading the authors to conclude that this increase was due to greater recruitment of higher order motor units, greater synchronization of the motor units and low presynaptic inhibition. However, the performance-enhancing factors observed in previous studies (31-34) were found in athletes, not in a sedentary population as in the present study. Notably, the aforementioned studies (31-34) usually analyzed the effect of elastic band warm ups on large muscle groups in multi-joint exercise, contrasting to the muscle groups analyzed in our study. Therefore, these methodological elements (i.e., sedentary vs. athletes; small muscle group vs. large muscle group; single-joint vs. multi-joint) could help explain the different results found in this work and those previously published (31-34).

Current results shows that the specific warm up with a therapeutic ball (squeezing-ball warm-up) had no effect on MHS when compared to the control condition. . A specific warm up involves skill exercises which demonstrate equivalency with the targeted motor task (35). It seeks to increase performance (36) via increases in muscle temperature, reductions in muscle viscosity resistance and greater nerve transmission speed (37). In a study conducted by Andrade et al. (38), the effects of a general warm up, a specific warm up and a combined warm up on explosive muscular performance were compared, with improvements in squat jump and drop jump being observed after a specific jump-based warm up. Similarly, in a study conducted in volleyball players, an improvement in countermovement vertical jump was observed after a specific warm up protocol based on jump exercises (39).Of note, the improvements in jumping performance after specific jump-based warm ups were observed in large muscle groups. Smaller muscles, such as the forearm, are composed of a significant number of slow-twitch muscle fibers that require a low motor unit firing frequency (i.e., 5 to 30 Hz), unlike other larger muscle groups (40). Such slow-twitch fibers are easily excitable (41) and so require lower levels of stimulation to achieve maximal activation and, therefore, maximal strength. Therefore, as muscular forearm activation in hand-grip tasks is relatively easier (42) as compared to larger muscle groups, a specific warm-up may not add to the performance of such muscle group during hand-grip tasks.

Of note, no differences were observed in MHS after dynamic (i.e., elastic band) and isometric (i.e., static stretching; isometric therapeutic squeezing-ball) warm-up protocols. Such observation seems to be in contrast with the findings of a previous study (43), where a dynamic warm up, when compared to static-stretching warm up, improved power and agility (T-shuttle run, underhand medicine ball throw for distance, and 5-step jump) in male and females military cadets. However, it should be acknowledge the methodological differences between studies, such as the participant's characteristics (i.e., females vs. mix sample of male and females), physical fitness level (i.e., low vs. high), type of performance test (i.e., maximal isometric strength vs. dynamic power test), among others. In this regard, the American College of Sport Medicine indicated that more controlled studies are needed to substantiate the effectiveness of warm-up protocols (44). The lack of consensus may be partially related to the different methodological issues previously indicated, as the effect of warm-up may vary according to such elements (45). Moreover, most studies related to warm-up strategies have been conducted in athletes (45). In this sense, the present results expand the limited knowledge available about the effect of different warm up protocols on the MHS in sedentary and overweight females.

Limitations, strength and practical applications

A limitation of the study was the sample size, as it may not have allowed statistically significant findings to be observed. Future studies may aim to replicate the current findings with a greater sample size. Additionally, in order to better understand the underlying mechanisms of different warm-up protocols, future research may include biomechanical as well as physiological measures related to the responses of forearm muscles to different warm-up protocols in sedentary and overweight females.

Conclusion

Warm-up of the forearm muscles does not acutely increase isometric MHS in sedentary overweight females in the dominant, or the non-dominant hands. Three isometric attempts, without warm-up, allows the achievement of MHS, with high reliability, serving as a time-efficient measurement protocol, with high applicability in clinical assessment.

Conflict of interest

This study did not have any conflict of interest.

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